the metal surfaces. There are other relevant factors, but their influence in general is subordinate to those mentioned. Dissolved oxygen, acid gases, and chloride salts are the corrosion accelerators most frequently encountered.

Neutral and slightly alkaline waters saturated with air, corrode iron at a rate about triple that for the same water free of air. Hot water containing oxygen will corrode iron at a rate three to four times that for the same water when cold.

Corrosion of iron decreases as the *pH* of water solutions increases, and practically ceases at a pH of 11. If the metal contains film forming agents, such as chromium, nickel, and silicon, or if the water contains inhibitors such as silicates and chromates, corrosion may in some instances be minimized.

Soft water, as for example the effluent from zeolite softeners, is likely to be several times more corrosive to iron than hard waters. In small installations, the use of copper or brass pipe usually is a practical expedient. Cement-lined pipe and tanks suitably resist attack.

Where the water contains slime-forming organisms, especially those bacteria that thrive on iron, chlorination of the water is imperative to inhibit tuberculation and subsequent pitting.

Bitumastic paints, applied at *regular* intervals upon *well cleaned* surfaces, will measurably prolong the life of equipment handling cold waters.

Pipe Materials. Brasses with 60 to 67 percent copper are dezincified in some corrosive waters, and in certain localities are not much more serviceable than galvanized iron or steel pipe. The zinc in brass pipes is leached out locally, leaving a plug of porous copper. The weakening of such pipe is especially noticeable under the threads. Dezincification is retarded by the use of silicate of soda (8 ppm added silica).[17]

In salt or fresh water, there is no material difference in rate of pitting of wrought iron, steel, low metalloid steels, or copper bearing steels. This is contrary to the relative performance of these metals in atmosphere.

Once Through Systems

Corrosion prevention in once through systems is obtained by any one of or a combination of the following methods.[12]

1. Forming a protective film of calcium carbonate on the metal surfaces.
2. Mechanical or chemical deaeration, or both, of the water.
3. Use of organic or inorganic corrosion inhibitors, or both, in low concentrations.

Formation of a thin protective calcium carbonate film is accomplished by adjustment of the water until the Langelier Index has a value greater than +0.5. This is rather difficult in systems which have a wide variation in temperature. Since the Langelier Index is dependent on temperature, when a water is adjusted to form a protective film on those surfaces of higher temperature, no film will form on colder surfaces. Therefore, this method of corrosion control is more applicable to large municipal distribution systems. Where heat transfer is involved, the method is usually impractical except under unusual circumstances. When this method is used, *pH* is increased by using an inexpensive alkali such as lime, caustic soda, or soda ash. Lime is usually used for waters of low calcium content. Caustic soda or soda ash are used for waters of high calcium content.

Mechanical[18] and chemical deaeration are not often used in once through systems because of relatively high operating costs. Mechanical deaeration also requires the use of costly equipment. Chemical deaeration is usually accomplished by raising *pH* with caustic soda and by continuously feeding catalyzed sodium sulfite in proportion to water flow. The use of catalyzed sulfite is not permitted in water to be used for potable purposes.

There are several corrosion inhibitors such as chromate, polyphosphates, and silicates which are effective in once through systems.[19] Chromates are not usually used because, when maintained at an effective concentration of 300–500 ppm, their cost is prohibitive. It has been found that the use of polyphosphate at a concentration of 2–5 ppm is effective in controlling tuberculation of iron pipe and in reducing overall corrosion.

The use of chromate-polyphosphate concentrations at less than 60 ppm has also proved effective. Under no circumstances may chromates be used in potable water systems.

Sodium silicate is often used in relatively soft waters by increasing the silica content about 8 ppm. It is used primarily to reduce corrosion in potable water supply systems.

Open Recirculating Systems

Corrosion in open recirculating systems, such as air washers and cooling towers, is usually controlled by use of corrosion inhibitors such as chromates polyphosphates, a combination of chromate and polyphosphate, and nitrites.[20, 21] Mechanical or chemical deaeration is not practicable in open systems because of the high rate of aeration. It is not practicable to use high *pH* values of 11 or more in systems containing wood. High *pH* will cause serious delignification of wood. High *pH* values also prevent control of scale. Corrosion control is usually carried out in the *pH* range of 6.5–8.

Chromates are by far the most effective corrosion inhibitors. It is extremely important, however, to maintain an adequate concentration of 300–500 ppm, which is effective for most systems. If for economic reasons substantially lower concentrations are used, serious pitting corrosion may occur.

Polyphosphates are most effective in reducing tuberculation. It is not usually possible to reduce overall corrosion to anywhere near the degree possible with chromate.

Where economy of treatment is of primary importance, a substantial reduction of pitting and overall corrosion can be obtained by using as little as 60 ppm of a mixture of polyphosphate and chromate. Close control over *pH* is a requirement for good corrosion control by this process.

Sodium nitrite has not had widespread use as a corrosion inhibitor in open recirculating systems. It has been reported that difficulty may be encountered in maintaining effective concentrations. Considerable field experience is needed to further qualify this inhibitor.

Closed Recirculating Systems

The term Closed Recirculating System is in reality a misnomer. Except for relatively small systems, most closed systems are open because they most usually require make-up water. Recently, tests conducted on 84 closed systems indicated that more than 50 percent of the systems had one or more water changes per month because of leakage. Weekly water changes were found in more than 10 percent of the systems.[22] Continuous make up, of course, replenishes oxygen in the system, thus promoting